

**DEVELOPMENT OF A DIRECT EXCHANGE  
AREA ESTIMATION ALGORITHM FOR  
RECTANGULAR ENCLOSURES**

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September 2015

## DECLARATION

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## ABSTRACT

Conduction, convection and radiation are the principle modes of transferring heat from a source to sink. In a furnace, when the operating temperature is above  $1000^{\circ}\text{C}$ , radiation heat transfer will be the predominant mode of transferring the heat. For such a furnace, estimating the radiation heat transfer accurately is essential. To estimate the heat transfer in the absence of participating medium, obtaining radiation properties of surfaces, temperatures of surfaces and view factor between surfaces is necessary. When participating media is concerned, it mainly consists of  $\text{CO}_2$  and  $\text{H}_2\text{O}$  due to fossil fuel combustion. Mixtures of these gasses are typically participating in radiation heat transfer process with different emissivity values at different temperatures. Therefore, view factor concept will not be accurate in such an instant. Direct Exchange Area (DEA) is introduced to cater for participating medium involved problems. To evaluate the radiation heat transfer with participating medium using zonal method, it is essential to determine the DEA values. Direct integration and Monte Carlo are the main methods to evaluate view factor. However, Monte Carlo method is not viable to apply for simple shapes such as rectangular enclosures due to large time consumption and computer storage requirement. Thus, direct integration is a good approach to find DEAs for simple geometries.

Surface to surface zones (**SS**), surface to volume zones (**SG**), volume to volume zones (**GG**) are the scenarios which needed to be determined in DEA estimation. Generalized mathematical equations for DEAs were simplified by using vector algebra with considering the simple shape of rectangular furnace walls. Further simplification could be done by reducing the integration scheme. Later, computer programming has been used to estimate the DEA values which is based on numerical techniques.

The resulting programming code is based on Matlab software, which has been developed to determine DEAs for each and every zones surface and volume which will be decided by the user. Estimated DEAs are not available in literature due to its dependency on area and absorption coefficient variable selected by the user. However, programming code based results validation can be done in two ways. One way is to convert DEA values for surface zones in to view factors by avoiding the effect from participating medium. Then the evaluated results can be compared with well known literature. Secondly, a mathematical relation which will be explained in literature can be used to compare overall results.

The computer based program was sophisticated with a user friendly interfaceso that the user or the designer does not need to worry about what is happening inside. The calculated result will later be transformed in to matrix form which can be directly used on estimation of heat transfer.

For future work, improvement of developed software interface to perform in optimum condition, enhancing with more features to cater for scattering situations, handling of garbage input by user, reducing the effect on higher absorption coefficient on the results were suggested.

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## NOMENCLATURE

A	=	Area
b1,b2,b3	=	constants
E	=	Energy flux
Fij	=	View factor from i surface to j surface
g	=	gas
H	=	irradiation
J	=	radiosity
k	=	transmissionfactor
q	=	Heat flux
s	=	Vectorized distance
S	=	Scalar distance
V	=	Volume
w	=	Wall
x	=	direction of x
y	=	direction of y
z	=	direction of z

### Greek Letters

$\alpha$	=	thermal diffusivity in convection / absorptivity in radiation
$\rho$	=	Transmissivity
$\mu$	=	kinematic viscosity
$\varepsilon$	=	Emissivity
$\mathbf{\varepsilon}$	=	Emissivity matrix
$\sigma$	=	Stefan Boltzmann constant
$\gamma$	=	Reflectivity
$\tau$	=	Transmissivity

## LIST OF ABBREVIATIONS

<b>DEA</b>	Direct Exchange Area
<b>CPU</b>	Central Processing Unit
<b>VF</b>	View Factor
<b>SS</b>	Surface to Surface DEA factor matrix
<b>GS</b>	Gas volume to surface DEA factor matrix
<b>GG</b>	Gas volume to Gas volume DEA factor matrix

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